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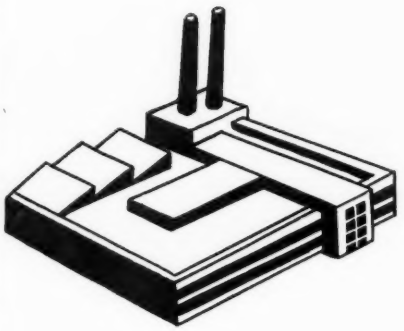
# *Application of Scientific and Laboratory Techniques*



## IN INDUSTRIAL HYGIENE

**BY KINGSLEY KAY, M.A., Ph. D.**

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*A Lecture read to the Refresher Course in Industrial Medicine — School of Hygiene, University of Toronto, March 8, 1960.*

In this lecture it is proposed to outline the role of scientific and laboratory techniques as an aid in protecting the health and productivity of working people. The scope of application of science in this field is broad and may be expected to increase in importance as technical advances take place in industry and agriculture. There are now many work situations with intrinsically dangerous materials and procedures where safety and health are assured owing to the application of scientific methods of protection. There are also many work situations now where health problems have been solved because scientific procedures have become available for use in selection of workers so that their capacities and characteristics may be matched to the job. In this way, factors leading to accident proneness or hypersensitivity to toxic agents and other such problems may be evaluated before placement.

The scope of application of scientific and laboratory techniques in this field covers the following aspects:

1. Assessment of physical hazards in the work environment including temperature, humidity, noise, lighting and radiation.

2. Assessment of chemical hazards in the work environment from toxic raw materials, intermediate and finished products including evaluation of skin exposure and levels in air.

3. Tests of efficiency of operation of hoods, shielding and other protective measures.

4. Tests of efficiency of respirators, goggles and such personal protective devices.

5. Design of protective procedures and equipment including safe process methods, substitution of safe for unsafe agents and other such procedures prior to operation of new processes when possible.

6. Design of plant facilities and processes in accordance with human engineering principles to reduce monotony and fatigue and to maintain highest productivity.

7. Scientific and laboratory test procedures in preemployment and periodic examination of working people and in diagnosis and preventive medical care on the job.

8. Study of fundamental behaviour of physical agents, gases and particulate matter in interaction in the atmosphere.

9. Study of safe standards for hazardous physical agents and maximum allowable concentrations of toxic chemicals and dusts in air.

10. Research on mechanisms of entry into the body and the mode of action of dangerous chemical and physical agents.

11. Development of new diagnostic methods, analysis of biological fluids, air samples or techniques for assessing physical factors.

12. Development of antidotes, therapeutics and prophylactics against dangerous chemical and physical agents.

In each industry some of these aspects will bear a relation to the health of the working people and industrial physicians will understand their implications in particular industries. Therefore, no attempt will be made systematically to describe applications of scientific and laboratory techniques to the health problems of the many specialized branches of industry. Instead, it is proposed to review a few cases in which new techniques have been employed

*Reprinted with permission from Canadian Medical Services Journal, June, 1960.*

or in which important problems have been successfully dealt with by scientific means. These cases, drawn from Canadian work wherever possible will exemplify some of the categories described above. After the review, a division of scientific and laboratory services appropriate to the industrial health field will be outlined and suggestions will be made as to how such services might be secured for industries of different sizes. In other words, this lecture is not primarily intended to instruct in industrial hygiene but rather to be a demonstration of what can be done with scientific and laboratory techniques.

### *Toxicity Data for Hazard Evaluation*

One of the most important problems in industrial hygiene relates to the assessement of toxicity of mixtures. Pure materials are not usually met with in industry. Grades are more likely to be the so-called technical type with a small percentage of process impurities present. Factory air is rarely contaminated by only one foreign material. Working people are generally exposed to a number of chemicals as well as to physical stresses. Are the effects additive in a simple arithmetic or proportional way? Does the effect of one perhaps work in opposition to the effect of another? Do two together potentiate? These are fundamental questions in evaluating toxicity currently and can best be approached scientifically.

#### *(a) Impurities*

It is common practice to evaluate the toxicity of a material from knowledge of the proportional amounts of active ingredients it contains, especially where a substantial proportion of associated materials is inert. Several years ago in Canada we found that toxicity tests should be carried out on the actual formulation rather than only on the active material. In a study of the toxicity of the insecticide aldrin by Ball, Kay and Sinclair (A.M.A. Arch. Ind. Hyg. and Occup. Med. 7, 292, 1953), the toxicity of a 2.5% formulation was being calculated from the $LD_{50}$ of the crystalline material. It was decided to use the 2.5% formulation in an actual $LD_{50}$ test. Two such formulations, bought on the open market, were used. There was agreement with calculated value in one case but in the other a four-fold difference. On investigation of the lot numbers with the manufacturer, it was found that the technical aldrin used in the formulations had been made by different processes. In one case a high toxicity impurity was present.

A recent example of this problem has been described by Friess, Jenden and Tureman (A.M.A. Arch. Ind. Health 20, 253, 1959), who found statistically significant variations in toxicity between batches of triarylphosphate oil. This was attributed to differences in source of the cresylic acid mixture used in manufacture of the oil.

It is evident that in assessing the toxicity of raw materials, intermediates and finished products, the toxicity of pure active ingredients should not be relied upon. The actual materials handled by personnel should be tested and different batches of material should be examined.

#### *(b) Synergism or Potentiation*

Another interesting aspect of the assessment of toxicity of industrial materials is the phenomenon of synergism or potentiation where association of materials yields a toxicity higher than would be expected on the basis of calculation from the toxicities of the ingredients. This phenomenon is well-known to pharmacologists and there are numerous examples in therapeutics. In entomology, DDT and pyrethrin have been found much more toxic together than their separate toxicities total. The same phenomenon has been reported in the field of industrial hygiene. For instance, alcohol has been regarded as a potentiating or a predisposing substance in relation to the toxicity of such materials as carbon tetrachloride, calcium cyanamide and carbon monoxide. The literature was considered last year by Pecora (Am. Ind. Hyg. Assoc. J. 20, 235, 1959), who also reported on experiments with carbon monoxide and ethyl alcohol.

#### *(c) Potentiation with Inhaled Particles and Gases*

The physiological effect of a combination of inhaled particles and gases has been the subject of much research. As early as 1939, Dautrebande showed that inhaled particles could potentiate the effect of irritant gases on the lungs. This was confirmed in 1955 by Labelle, Long and Cristofano (Arch. Ind. Hyg. and Occup. Med. 11, 297, 1955) and in 1957 by Pattle and Burgess (J. Pathol. Bacteriol. 73, 411, 1957). In the same year Amdur (Am. Ind. Hyg. Assoc. J. 18, 149, 1957) found a similar effect on guinea pigs using sulfuric acid mist and sulphur dioxide. It was found by Amdur that the degree of pulmonary flow resistance produced by sulphur dioxide especially at levels below 25 p.p.m. was potentiated in the presence of comparable concentrations of sulfuric acid aerosol, (i.e., the effect was greater than that calculated on the basis of proportionality). The potentiation only occurred when the aerosol particle size was below 1 m diameter. Inert NaCl aerosol also potentiated the action of $SO_2$ on pulmonary flow resistance at particle sizes below 1 m. Last year Amdur reported (Int. J. Air Pollution, 1, 170, 1959) that the effect of formaldehyde was potentiated by NaCl aerosol but acetic acid and formic acid vapours were not. In all cases the presence of aerosol prolonged the flow resistance beyond that produced by the gases alone.

#### *(d) Chemical Interaction in Air*

It is desired to make reference to chemical interaction studies by Johnstone at the University of Illinois in which a chemical reaction between air-borne materials produced higher toxicity products. This investigator showed in 1958 (Johnstone, H. F., Coughanowr, D. R., Ind. Eng. Chem. 50, 1169, 1958) that the presence of iron and manganese salts in droplets in air containing $SO_2$ lead to the formation of $H_2SO_4$ droplets. Last year Johnstone and Moll studied the rate of formation and found that only

when fog was present — and hence droplets containing Mn and Fe in the liquid phase — would $H_2SO_4$ be formed. The conversion occurred at a rate of 1% $SO_2$ to $H_2SO_4$ per minute, concentrations of $SO_2$ being 250 ppm and catalyst being present at the level of 2 mg/m$^3$. Phenol vapor reduced the efficiency of the reaction, presumably by poisoning the catalyst. NaCl nuclei brought about a slow but significant conversion of $SO_2$ to $SO_3$ without catalyst present just below saturation but no conversion at 94 percent relative humidity. It is considered that these findings may throw light on the toxic action of smog and they suggest that the possibility of interactions of atmospheric contaminants in work situations should never be ignored.

#### (e) *Antagonism and Reduction in Toxicity*

An important example of reduction in toxicity through association of two chemicals is exemplified by the well-known aluminum therapy technique. This was derived from laboratory experiments in 1932 by E. H. Kettle, (J. Path. and Bact. 35, 395, 1932) who found that iron oxide coating could make quartz dust harmless to guinea pigs. In 1937, Denny, Robson and Kettle (Can. Med. Assoc. J. 37, 1, 1937) reported on experiments in which rabbits dusted for six months with a mixture containing 1% aluminum powder in quartz failed to develop silicosis, whereas rabbits treated with quartz alone developed the disease. A further paper in 1939 by this group (Denny, J. J., Robson, W. D., Irwin, D. A., Can. Med. Assoc. J. 40, 213, 1939) showed that no animal whose lungs on analysis contained 1% or more of metallic aluminum had shown any evidence of silicosis up to periods of 17½ months, in contrast to well-developed silicosis in the quartz control rabbits in seven months. The subsequent application of these laboratory findings in the protection of workers exposed to quartz dust is well-known and will not be described here.

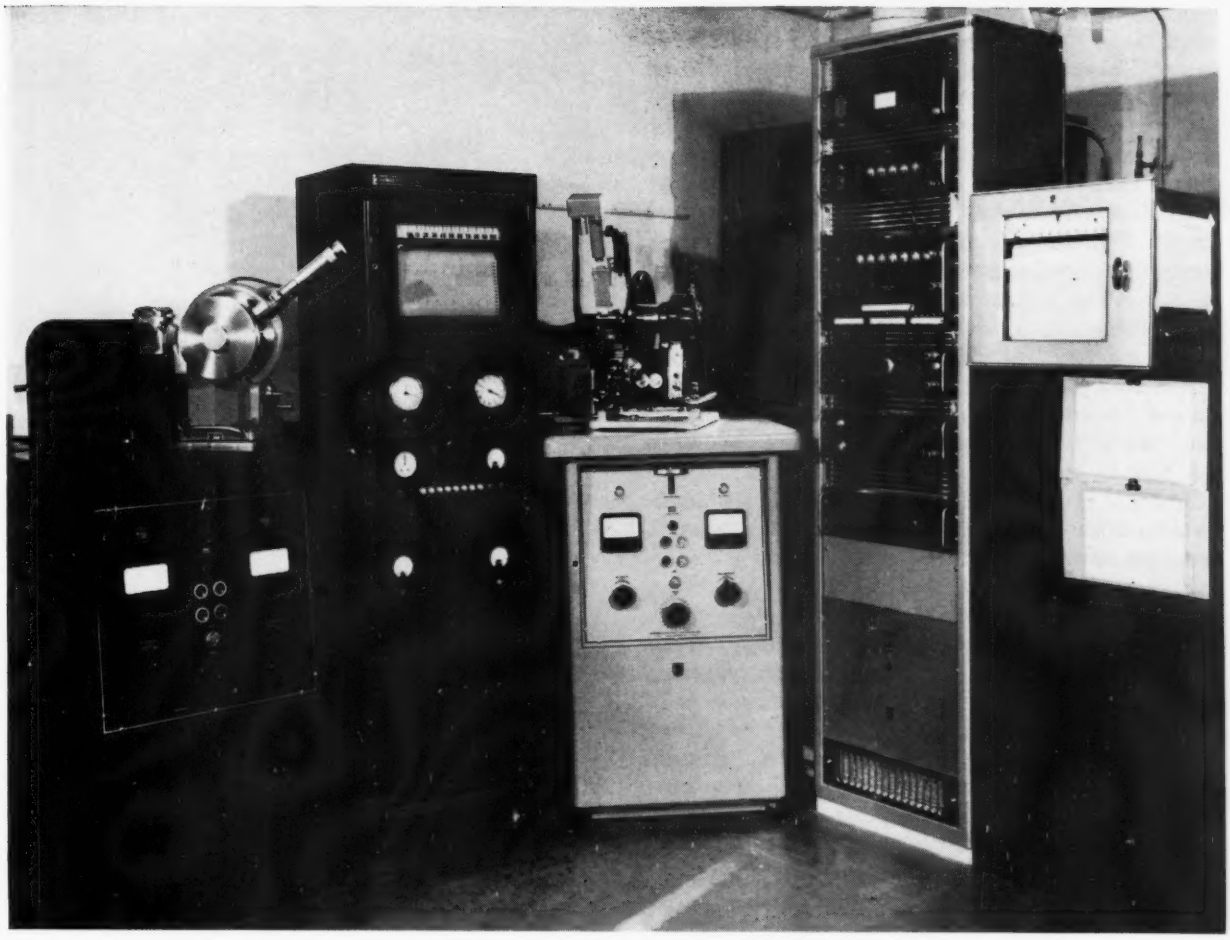
Still another effect, antagonism of toxicity between two chemicals in vivo, has been described by Ball, Kay and coworkers (Can. J. Biochem. and Physiol. 32, 440-5, 1954). It was discovered that the toxicity of parathion could be grossly modified by pretreatment with aldrin to the extent of reducing toxicity seven-fold. Some small modification of acute oral toxicity occurred on simultaneous administration, but as the mechanism of the action of aldrin was slow the effect was small in this instance. Whether aldrin or a less intrinsically toxic material could be used prophylactically in protection of humans against parathion was never discovered as this work was not carried to the clinical level. Recently, Wilson and Nachmansohn at Columbia have developed a prophylactic and antidote for poisoning by the nerve gases of which parathion is an example. Whereas atropine merely reduced the sensitivity of nerve, muscle and gland receptors to acetyl choline, the new compound, pyridine aldoxine methiodide causes the release of the enzyme from the poison. It attaches itself at one end to the phosphorus group and at the other end to the anionic (choline seeking) site on the enzyme to free the nucleophilic or esteratic (acetyl seeking) site.

To summarize, the assumptions that contaminants will coexist without interaction and that toxicities of mixtures can be regarded as proportional to the ingredients are misconceptions that have existed widely in the industrial hygiene field for many years. It is evident that laboratory research has contributed much to bring these misconceptions to light — and that health evaluation where chemicals occur in industry and agriculture must be made scientifically as well as clinically, to determine what materials are present and whether interactions are occurring in the environment or in the body.

### *X-ray Diffraction in Industrial Hygiene*

Shortly after the war X-ray diffraction was found to be an analysis tool of great value in industrial hygiene. In this physical phenomenon, crystals and crystalline materials reflect x-rays in a manner characteristic of their molecular structure. For example, there are several forms of $SiO_2$— quartz, having one crystal form tridymite another cristabolite, another and non-crystalline or amorphous $SiO_2$. The first application of X-ray diffraction in industrial hygiene related to the determination of quartz. Existing chemical methods for determining $SiO_2$ failed to differentiate between the various forms which differ toxicologically. Furthermore, $SiO_2$ is a chemical constituent of a vast number of silicates. Existing physical methods were unsatisfactory as characteristics of the different crystal forms of $SiO_2$ and silicates were too closely similar, especially for differentiation of very small particles. X-ray diffraction was a phenomenon in which a striking difference existed between the angles of reflection of quartz and other forms of $SiO_2$ and silicates. The ease with which it became possible to have industrial and mine dust analyzed for quartz content was a tremendous aid in control programmes for reduction of silicosis.

In Canada, a number of contributions have been made in the method of using X-ray diffraction for analysis. A uniquely rapid and accurate method for determining crystallites such as quartz in industrial dusts was developed (Kay, K., Am. Ind. Hyg. Assoc. Quart. 11, 185, 1950). New applications in the environmental field were the subject of special study and a report on these was published in 1953 (Lennox, D. H., Leroux, J., Arch. Ind. Hyg. and Occup. Med. 8, 359, 1953). The use of X-ray diffraction in establishing identity as between a dust in the air and the dust laid down in the lungs of fatal silicosis or pneumoconiosis cases was one interesting application.This has aided in identifying the aetiological agent in pneumoconiosis cases which heretofore had often presented difficulties as regards establishing the role of the work exposure. The use of diffraction tracings in identifying arsenic trioxide and other constituents collected in a bag house type filter was also demonstrated. The spectro-



meter diffraction patterns of a number of toxicants occurring as dangerous dusts in the industrial hygiene field were found. These contours permitted clean-cut identification and good quantitation of crystalline toxicants in a dust. The use of X-ray diffraction for identification of insecticides in dust formulations was also successfully evolved.

The health hazard of chemicals can rarely be assessed or controlled without knowledge of the level of concentration in the air. Thus, analytical methods are of fundamental importance and their development is a necessary scientific accompaniment to the practice of industrial medicine.

### *Design of the Safe Working Environment*

It is the accepted goal of industrial hygiene to obtain environmental conditions within normal limits. This goal can be approached by the application of a number of scientific procedures. Remarkable safety and health records have been made by many companies, notably in the chemical industry (Kay, K., Int. Labour Rev. LXXII, 3, 1955). These records have been the result of experiment to obtain rational design of equipment and procedures in relation to the assessed hazard of processes, raw materials, intermediates and finished products. In the successful enterprises, of course, such an approach has been combined with the use of scientific techniques for selection of personnel having the most suitable characteristics for the job to be done. There is, in fact, no evidence to indicate that the financial success of a single undertaking has ever been impaired by a high standard of working conditions or by providing the most up-to-date test facilities for the medical departments.

The need for scientifically designing even outdoor equipment to meet safety and health standards was well-exemplified in the studies made by our group in the Quebec orchards several years ago when the toxic insecticide parathion first came into field use (Kay, K., Arch. Ind. Hyg. and Occup. Med. 6,252, 1952). In spite of the advantage of the outdoor situation many orchards workers showed significant reduction of blood cholinesterase and clinical signs of a response to the toxic material handled. An assessement of equipment in use (Kay, K., Can. J. Publ. Health 46, 273, 1955) revealed many design features which exposed the operator to excessive contact with the loaded

chemical, features which were not crucial for proper operation of the machinery. This was specially true in aircraft dissemination. It was evident that the tocixity and physical characteristics of material to be disseminated had not been considered in the design of the equipment. Furthermore, the equipment was being used by the grower without consideration of the toxic potential of the active material. A rational study of the equipment taking into account health aspects made it possible to lay down a number of design features for new equipment which would yield safety in operation with toxic materials.

Another interesting example of hazard assessment and appropriate design to meet the hazard is the case of a recently built United States plant for processing chrome ore and converting it into sodium chromate and bichromate (Hatch, T., Chem. and Eng. News 32, 2994, 1954). This type of operation has long been recognized as a major cause of chrome ulceration and, in view of accumulating evidence of the carcinogenic effects of certain chromium chemicals, it warranted the detailed and comprehensive efforts that were made to ensure safe working environment for the operating staff.

In this plant there was a series of operations, each giving rise to effluents of a potentially hazardous character. The primary operation involved the handling and processing of solid materials. Then followed roasting and delivery to leaching departments. These processes required arrangements for the control of dust. Leaching and liquor processing yielded the chromates, and special equipment was necessary for the control of mists and dried residues from droplets. The subsequent crystallization, drying and packaging processes also demanded dust control.

Basic characteristics in the process that might have caused unhealthy working conditions were determined in advance, and steps taken to avoid these hazards. It was noted that hazardous working conditions may be recognized in advance, though in general this fact receives only secondary consideration in design. It was emphasized that hygienic factors should receive the same basic consideration in the course of analysis and design as requirements for the satisfactory performance of equipment in a physical sense. Four principles to aid in design were formulated —

(1) At the outset, every step in the series of processes was to be examined in respect of its capacity to produce and release contaminants. As far as possible, procedures would be selected having the least inherent capacity for forming or permitting the release of hazardous material.

(2) In the case of equipment that was expected to release toxic material, the amount was to be kept at a minimum by the best selection of equipment and, if necessary, by making suitable alterations in design and construction.

(3) Where the potential escape of hazardous material could not be eliminated or minimized by a change in the fundamental process or by modification of equipment, the objective was to build accessory control measures into the equipment.

(4) Control equipment was to be such as would require the least possible maintenance compatible with efficient operation.

It was found that control measures alone are usually not enough to ensure safe working conditions. The methods of operation, proper maintenance of equipment and orderliness in the work place are equally important. From the beginning, the dual responsibilities of the engineering and production departments were recognized, and a program of operation was planned in which the importance of safe working conditions was constantly taken into account. In order to control dust, for example, a central vacuum cleaning installation was provided with convenient hose connections to collect dust in all areas where it might be spilled on the floor and to permit cleaning out the inside of equipment before repair and maintenance was begun. No major changes from the original designs of several ventilation systems were found necessary except on bagging operations, where it was decided to meet the hazard by making improvements in packaging methods. Finally, collection equipment served to recover material that would otherwise have been wasted in the atmosphere — a most important practice applicable in many cases.

The assessement of hazard in new operations at the design and development stage obviously depends upon knowledge of the toxicity of the chemicals involved in the various processes. The more toxic the chemicals, the more stringent the measures must be to prevent their escape to the air in the workroom and to reduce contact with the skin.

In the case of the older materials a substantial body of information on toxicity has accumulated over the years through research on experimental animals and observation of the health experience of exposed workers. From this knowledge it has been possible to establish environmental standards indicating the maximum amounts that can be inhaled without ill effects. These standards, the so-called "maximum allowable concentrations" or "threshold limits", are generally estimated by combining the results of laboratory experiment and clinical experience and are of great practical importance, since in many instances the complete retention of chemicals within process equipment is not possible, and the designer must therefore have a guide to the maximum amounts that can be tolerated in the air.

Measures for the prevention of skin contact have to be designed on an empirical basis, since no standards have yet been established comparable to the theshold limits with respect to inhalation. Elimination of contact by automation is often the most satisfactory solution where toxic materials of high dermal penetrating power or sensitising activity are concerned.

The importance of ensuring that provision for proper environmental conditions be made in plans for new processes warrants the most serious consideration of industry, labour and governments. Industrial physicians have an important role to play in assisting management to take account of the human factor in designing facilities — for it is the industrial physician who reveals the results on health when design fails to provide the necessary protection of personnel.

### *SUMMARY*

It has been the purpose of the preceding review to demonstrate that in the present technical era, health care of working people requires the use of scientific and laboratory facilities in several of the disciplines. The needs may be grouped under the following headings:

Toxicology and dermatology
Physiological and psychological hygiene
Ophthalmology and Otology
Industrial Hygiene Engineering
Chemistry and Physics.

There are a few large industrial concerns in the United States having laboratory, engineering and medical organizations capable of providing service in these categories. The bulk of industries and unorganized agriculture have requirements of a widely diversified nature which cannot be met in their own organizations and have to be sought outside as needed. This is generally the case in Canada where industries are small. At the present time the Departments of Health are not staffed and equipped to assist in all the needed areas of scientific and laboratory service. The universities are possibly closer to this goal having the basic departments in most instances though without the specialized knowledge for application to the health problems of working people except in a few centres. The Department of National Health and Welfare in Ottawa has lately undertaken a special effort toward the solution of this problem. An attempt is being made to assist the universities in development of research and teaching in areas useful to industrial physicians. This is being done by providing professional and financial aid. It is felt that industry and unions will ultimately take part in this development program, recognizing that from the universities will come consultants as well as career specialists in the different branches of the field. Furthermore, industrial personnel will go to the universities to secure training in new aspects as in the instance of the present refresher course. Such university development will assist Departments of Health in much the same way but will be particularly useful for increasing the range of services of local health units upon whom agricultural and mining personnel will have to depend for health protection in outlying areas of the country.

Apart from university developments it would appear that some advantage could be gained by having engineering and laboratory departments in the medium-sized industries generally undertake to embrace the safety and health fields as a recognized aspect of operations. Even the hospitals might develop laboratory services useful to local industry. Here, again, the universities will undoubtedly play a role by providing up-to-date instruction. Probably more clinical chemistry and special senses testing could be done in the smaller industries. For instance, industrial nurses have the basic training which would allow them to be instructed in these techniques. This would make it possible for the industrial physician to have more complete information especially on personnel exposed to hazardous conditions. Another idea which should soon be experimented with is a shared industrial hygiene laboratory service for a group of industries. This might be in industry or be provided from a local hospital.

The industry of Canada is growing and the growth is most evident in the number of small industries. This fact, taken with the very large geographical area of the population presents a difficult situation in regard to the provision of technical services.

# The L-E-N-G-T-H-E-N-I-N-G Life Span

**BY A. H. SELLERS, M.D., D.P.H.**

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The intensity and character of the need and the demand for health services is influenced to a large degree by demographic and social changes in our population. In common with other provinces of Canada and other countries, particularly in the Western World, the twentieth century has brought sharp changes in Ontario's population structure, in mortality and expectation of life, and in the character of the major health problems in terms of needs for services and facilities.

There have been three significant features in our health experience over the past fifty years: (a) large reductions in the mortality rate in all age groups under 70 years, especially in infants and in persons under the age of 50 years; (b) large reductions in both morbidity and mortality from acute infective diseases at all ages; (c) substantial prolongation of the lives of persons with chronic disease or disability as a result of more effective control measures, e.g., insulin for diabetes mellitus, liver extract for pernicious anemia, the use of antibiotics and certain surgical procedures.

### MORTALITY CHANGES

During the past fifty years, outstanding reductions in mortality have been made in Ontario. These reductions have been largely in the mortality from a comparatively few causes, spearheaded by the reductions in infant and maternal mortality, and in the mortality from the infective diseases (particularly diphtheria, tuberculosis and typhoid fever), respiratory diseases, rheumatic heart diseases, and appendicitis. Deaths from diphtheria declined from 722 in 1901 to 0 in 1958; deaths from typhoid fever fell from 500 in 1901 to 0 in 1958; deaths from tuberculosis dropped from 3,243 to 186 last year.

In the early years of the twentieth century over 20% of all recorded deaths were due to the infective diseases. This proportion has fallen in successive 10-year periods to 13.5%, 11.4%, 7.8%, 4.2% and 2.0% and in 1955-57 to 1.0% (Table I).

**TABLE 1 — MORTALITY FROM ALL CAUSES AND INFECTIVE DISEASES, ONTARIO, 1900-1957**

| Period | Deaths, All Causes | | Deaths, Infective Diseases | | |
|---|---|---|---|---|---|
| | Number | Rate* | Number | Rate* | % Total Deaths |
| 1900-02 | 83,756 | 1,279 | 17,172 | 262 | 20.5 |
| 1910-12 | 95,360 | 1,258 | 12,872 | 170 | 13.5 |
| 1920-22 | 109,025 | 1,238 | 12,475 | 142 | 11.4 |
| 1930-32 | 109,487 | 1,064 | 8,527 | 83 | 7.8 |
| 1940-42 | 116,848 | 1,023 | 4,905 | 43 | 4.2 |
| 1950-52 | 132,331 | 955 | 2,668 | 19 | 2.0 |
| 1955-57 | 141,829 | 870 | 1,409 | 86 | 1.0 |

**Per 100,000 population.*

This reduction, amounting to 95%, has been achieved by the collective effect of a number of causes, including improvements in water supplies and sanitation, decline in virulence of infective agents or increase in natural immunity, protection of the community by immunization procedures, improvements in medical care, personal hygiene, education and housing; new discoveries in chemotherapy.

The mortality changes have been characterized by a marked decline in the mortality rate in all age groups under 50 years, that in the 40-49 group amounting to over half of the rate in 1900-02; in the 30-39 age group to three-quarters; and in all age groups under 30 years to fully four-fifths of the rate in 1900-02 (Table II).

*Presented at the tenth annual meeting of the Ontario Public Health Association, September 28-30, 1959, Toronto, Ont.*

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**TABLE II — MEAN DEATH RATES BY AGE GROUP, ONTARIO — SELECTED PERIODS**

| Age | 1900-02 | 1940-42 | | 1955-57 | |
|---|---|---|---|---|---|
| | | Rate | Per Cent* | Rate | Per Cent* |
| 1-4 | 10.78 | 2.48 | 23.0 | 1.24 | 14.7 |
| 5-9 | 3.52 | 1.04 | 29.5 | 0.56 | 15.9 |
| 10-14 | 2.46 | 0.90 | 36.6 | 0.48 | 19.5 |
| 15-19 | 3.81 | 1.42 | 37.3 | 0.87 | 22.8 |
| 20-29 | 5.61 | 1.85 | 33.0 | 1.11 | 19.8 |
| 30-39 | 6.50 | 2.68 | 41.2 | 1.50 | 23.1 |
| 40-49 | 8.14 | 5.14 | 63.1 | 3.78 | 46.4 |
| 50-59 | 12.69 | 12.10 | 95.4 | 10.17 | 79.4 |
| 60-69 | 27.62 | 27.40 | 99.2 | 24.88 | 90.1 |
| 70+ | 95.83 | 92.03 | 96.0 | 81.32 | 84.9 |

*Per cent of rates in 1900-02.*

By contrast, the total death rates in the age-groups 50-59, 60-69 and 70 years and over have, until fairly recent years, shown very little change; particularly is this so among males (Table III).

**TABLE III — AGE-SPECIFIC MORTALITY RATES BY SEX,* ONTARIO 1930-32 vs 1955-57**

| Age | Males | | | Females | | |
|---|---|---|---|---|---|---|
| | 1930-32 | 1955-57 | % Change | 1930-32 | 1955-57 | % Change |
| Und. 1 | 8,207 | 3,023 | −63.2 | 6,492 | 2,327 | −64.2 |
| 1-4 | 495 | 135 | −72.7 | 423 | 114 | −73.0 |
| 5-14 | 175 | 64 | −63.8 | 130 | 40 | −69.0 |
| 15-24 | 268 | 143 | −46.7 | 229 | 53 | −77.0 |
| 25-34 | 337 | 159 | −52.8 | 328 | 83 | −74.7 |
| 35-44 | 487 | 273 | −43.8 | 458 | 174 | −62.2 |
| 45-54 | 904 | 799 | −11.6 | 793 | 458 | −42.3 |
| 55-64 | 1,992 | 2,071 | + 4.0 | 1,695 | 1,122 | −33.8 |
| 65-74 | 4,703 | 4,692 | − 0.2 | 4,031 | 2,937 | −27.2 |
| 75and over | 13,041 | 12,223 | − 6.3 | 12,588 | 10,325 | −18.0 |
| **Total** | **1,111** | **984** | **−11.4** | **1,015** | **755** | **−25.7** |

*Per 100,000 population.*

This fact may in part be due to the sub-standard people in these age groups saved from earlier death by the factors which have combined to reduce mortality at ages under 50 years. There is no justification, however, for "the cynical notion that the causes of death after age 65 are not of great importance".

### *Sex Differences in Mortality Trends*

There is a sharp sex difference in the mortality rates throughout the life span and these differences have been greatly accentuated in the last 25 years. While there has been a sizable reduction in female mortality in all age groups 50 and over, the changes in the male rates have in fact been negligible and the excess of male mortality over mortality for females has very substantially increased! The major portion of this male excess is due to accidents and to cardiovascular-renal disease.

## *EXPECTATION OF LIFE*

These several developments have had certain known results: (a) an increase in the average length or expectation of life; (b) an increase in both the absolute number and the proportion of persons alive at older ages; (c) an increase in the number of "sub-standard" individuals, i.e. those with disabilities and impairments, who reach older ages, e.g. persons with diabetes, pernicious anemia, rheumatic heart disease; (d) an increase in the prevalence, not incidence, of those diseases common to the older age groups, many of which are chronic in nature such as cardiovascular-renal conditions, neoplasms, diabetes, arthritis.

The expectation of life or average length of life expresses the mean duration of life to be expected by newborn infants or by people who attain a given age, or the average number of years that a person of a given age will probably survive, based on the assumption that the death rates will not change.

The average duration of life has progressively increased from ancient times, but it has increased more in the past century than in all prior centuries since the dawn of civilization. The average length of life of prehistoric man was perhaps 18 years. Longevity in Roman Egypt about two thousand years ago has been estimated by Karl Pearson to have been about 22 years. Figures for the Middle Ages suggest an expectation of life at birth of possibly 35 years. According to life tables constructed by Dr. William Farr for England and Wales covering the period 1838 to 1854, the average length of life had been increased to 40.9 years, a gain of a little more than five years over the figures for the Middle Ages. In the United States, the average length of life was 49.2 years in the period 1900-1902.

Spectacular gains in life expectancy were achieved during the first half of the twentieth century and today (in 1956) the expectation of life at birth in Ontario is 67.8 years for males and 73.6 years for females, gains of 6.5 and 9.7 years respectively in less than a generation (Table IV).

**TABLE IV — EXPECTATION OF LIFE AT CERTAIN AGES, BY SEX — ONTARIO**

| Year | Males | | | Females | | |
|---|---|---|---|---|---|---|
| | Birth | 50 | 65 | Birth | 50 | 65 |
| 1901 | 48.2 | 20.8 | 11.5 | 51.1 | 21.9 | 12.2 |
| 1931 | 61.3 | 23.3 | 12.7 | 63.9 | 24.5 | 13.5 |
| 1941 | 64.6 | 23.1 | 12.6 | 68.4 | 25.4 | 14.0 |
| 1951 | 66.5 | 23.2 | 12.8 | 71.6 | 26.7 | 14.8 |
| 1956 | 67.8 | 23.5 | 13.0 | 73.6 | 27.7 | 15.6 |

*Source: Life Tables for U.S.A. for 1901 and for Ontario for 1931, 1941, 1951 (tentative) and 1956 (tentative).*

To express this fact in a different way, under the mortality conditions which prevailed in 1901, a group of 100,000 male babies born in 1901 would be reduced to 39,245 by the time they reached their 65th year, while with the death rates of 1955-57 the number of survivors at age 65 in Ontario would be 67,409. In other words the chances of a boy born in 1901 celebrating his sixty-fifth birthday were less than 40 in 100. Today the chances are 67 in 100. For females the chances are 80 in 100. Under prevailing mortality rates, half the girls now being born will live to age 77 and half the boys to age 72.

During the last 55 years the expectation of life at birth has improved by 20 years for boys and by 23 years for girls. In 1901, a young man of 18 had 51 chances in 100 of surviving to 65; in 1956 this figure was 70 in 100. Medical and public health leaders could hardly have expected such gains within two generations. Even in the last 15 years the average length of life has increased by three years for males and by five years for females.

### *Expectation of Life at Various Ages, By Sex*

Most of the gains in expectation of life have been made at ages under 50 years (Table V).

There has been comparatively little gain in the expectation of life in the age groups 50 and over, and here the sex differences continue to be sharp. For males, the expectation of life at age 65 is greater now by only 1.5 years than it was in 1901; for females it is greater by 3.4 years. At age 50 it is greater by 2.7 years for males and by 5.8 years for females, but in the past 25 years, i.e. since 1931, the gain in life expectancy for males at age 50 is only about three months compared with three years for females. A similar differential exists at age 65.

The difference between the male and the female expectations has grown progressively wider over the years, amounting now to almost six years at birth, four years at age 50 and two and one-half years at age 65.

The mean duration of life to be expected among baby girls born in Canada in 1956 was 73.6 years and for males it was 67.8 years; at age 50 the expectations were 27.7 and 23.5 years. The average length of life remaining to Ontario males at age 65 is 13.0 years; for females 15.6 years. The more vigorous will of course live much longer than the average.

**TABLE V—THE GAIN IN LIFE EXPECTANCY, ONTARIO, 1930-32 TO 1955-57**

| Age | Male | | | Female | | |
|---|---|---|---|---|---|---|
| | 1931 | 1956 | Gain | 1931 | 1956 | Gain |
| 0 | 61.3 | 67.8 | 6.5 | 63.9 | 73.6 | 9.7 |
| 5 | 62.2 | 65.1 | 2.9 | 63.9 | 70.6 | 6.7 |
| 15 | 53.2 | 55.5 | 2.3 | 54.6 | 60.8 | 6.2 |
| 25 | 44.5 | 46.2 | 1.7 | 45.8 | 51.1 | 5.3 |
| 35 | 35.8 | 36.9 | 1.1 | 37.2 | 41.5 | 4.3 |
| 45 | 27.4 | 27.7 | 0.3 | 28.6 | 32.1 | 3.5 |
| 55 | 19.5 | 19.6 | 0.1 | 20.6 | 23.4 | 2.8 |
| 65 | 12.7 | 13.0 | 0.3 | 13.5 | 15.6 | 2.1 |
| 75 | 7.3 | 7.8 | 0.5 | 7.7 | 9.1 | 1.4 |

### *The Future Outlook for Longevity*

The outlook seems favourable for further gains in the expectation of life in the future. We still have a higher infant mortality rate than in England and Wales, United States, Sweden, Holland, New Zealand, and Australia. Wide application will be made of existing knowledge in medical and sanitary science and further advances will be made too in our standard of living, nutrition, housing conditions, protection against occupational hazards and accidents. All these forces can effect further reductions in mortality and thus improve longevity. Discoveries in the fields of cancer and the degenerative diseases could add significantly to the present average length of life.

## *CHANGES IN OUR POPULATION STRUCTURE*

Control of many infective diseases, better medical care, better education, better working conditions, better nutrition, hygiene and sanitation; all the forces mentioned have been responsible for a lowered mortality, a greatly increased life expectancy, and have played a large part in the profound modification of our population structure, which influences the whole picture of health and disease and which will affect the whole structure of our society.

Until fairly recent decades our population was characterized by its youthfulness. Heavy immigration of young men and women and high birth rates swelled the proportion of people in the younger age groups and diminished the relative importance of those in the age group 65 years

and over. Later, immigration was reduced, our birth rates declined and life conservation at the earlier ages brought more and more of the population into the older age brackets. In the post-war years immigration and sustained high birth rates, and particularly the latter, have combined to slow up the "aging" process due largely to the substantial increases in population under 20 years.

There is no arbitrary boundary between senility and old age. Many people at 65 are still vigorous and gainfully employed, while others are showing signs of aging. For convenience, however, the term "old" may be associated with those who have attained their 65th birthday.

Ontario's population has grown from just over two million in 1901 to 5.4 million in 1956 and it is still growing at the rate of about 200,000 or 3% per year. (Table VI).

percentage of the population 65 and over will decrease in the future; indeed, this trend is already evident (Table VI), falling from 8.7% in 1951 to 8.4% in 1956. By 1970, it is estimated that 8.1% of our population or one in 12 will be 65 years of age or over.

Another important effect of the reduction in our mortality rates is the greatly increased number and proportion of the population who survive to begin and to complete the working years of life. This tremendously important point is often obscured by the emphasis placed upon the problems of "old age". The improved mortality rates at all ages under 50 years ensure us a greatly increased number of years of productive work (Table VII).

The greatest proportionate increase in our population is in the age group 45-64 years. In 1901, 326,800 persons or

**TABLE VI — ONTARIO'S GROWING POPULATION** — 1901-1975**

| Census Year | All Ages | | Ages 65 and Over | | | Ages 20-64 | |
|---|---|---|---|---|---|---|---|
| | Number | Ratio to 1901 | Number | Per Cent of Total | Ratio to 1901 | Number | Per Cent of Total |
| 1901 | 2,182.9 | 1.00 | 120.6 | 5.5 | 1.00 | 1,147.4 | 52.6 |
| 1911 | 2,527.3 | 1.16 | 142.8 | 5.6 | 1.18 | 1,402.4 | 55.5 |
| 1921 | 2,933.7 | 1.34 | 172.3 | 5.9 | 1.43 | 1,621.0 | 55.2 |
| 1931 | 3,431.7 | 1.57 | 234.2 | 6.8 | 1.94 | 1,919.5 | 55.9 |
| 1941 | 3,787.7 | 1.74 | 301.3 | 8.0 | 2.50 | 2,223.0 | 58.7 |
| 1951 | 4,597.6 | 2.11 | 400.4 | 8.7 | 3.32 | 2,642.2 | 57.5 |
| 1956 | 5,404.9 | 2.48 | 454.4 | 8.4 | 3.77 | 2,985.3 | 55.2 |
| 1960* | 5,863.0 | 2.68 | 486.0 | 8.3 | 4.03 | 3,115.0 | 53.1 |
| 1965* | 6,555.0 | 3.00 | 538.0 | 8.2 | 4.46 | 3,386.0 | 51.6 |
| 1970* | 7,314.0 | 3.35 | 593.0 | 8.1 | 4.92 | 3,739.0 | 51.1 |
| 1975* | 8,184.0 | 3.75 | 661.0 | 8.1 | 5.48 | 4,192.0 | 51.2 |

* *Estimated population, Gordon Report.* ***In thousands.*

In the meantime the number of older people in our population has very substantially increased. In 1901 there were 120,600 persons aged 65 and over in Ontario; 30 years later, in 1931, this figure had doubled to 234,200 and 25 years later, by 1956, it had almost doubled again at 454,400. The number of people in the age group 65 and over is now approaching half a million and is increasing at the rate of 10,000 per year. It is estimated that in 1960 the numbers will increase to 486,000 and by 1970 to 593,000.

In 1901 only 55 persons in every 1,000 were 65 years of age or over. In 1931, the figure was 68 and in 1951 it was 87. Due to the continuing high birth rate since 1946 and substantial immigration, the relative but not absolute size of the older age group will tend to diminish and the

15% of our population were in the age group 45-64 years. At the 1956 census there were 1,012,200 persons or 19% of our population in the age group 45-64 years, and 454,400 or one in every 12 persons 65 years of age or over. By 1970 we will have something over 1,413,000 persons in the age group 45-64 years, and almost 600,000 at 65 years of age and over.

A useful measure of the impact of the lengthening life span and the aging of the population on our medical and public health commitments would be the numbers of retired individuals expressed per 1,000 persons in their working years. As an alternative we may use the ratios (per cent) of persons age 65 and over to the population at working ages and more specifically to males age 20-64 years (Table VIII).

**TABLE VII — ONTARIO'S POPULATION BY AGE — 1901-1970**

| Age | 1901 | | 1931 | | 1956 | | 1970 | |
|---|---|---|---|---|---|---|---|---|
| | Number | Per Cent | Number | Per Cent | Number | Per Cent | Number | Per Cent |
| 0-14 | 685.2 | 31.4 | 958.9 | 28.0 | 1,618.4 | 29.9 | 2,322.0 | 31.8 |
| 15-44 | 1,050.3 | 48.1 | 1,602.5 | 46.7 | 2,319.9 | 43.0 | 2,986.0 | 40.8 |
| 45-64 | 326.8 | 15.0 | 636.1 | 18.5 | 1,012.2 | 18.7 | 1,413.0 | 19.3 |
| 65+ | 120.6 | 5.5 | 234.2 | 6.8 | 454.4 | 8.4 | 593.0 | 8.1 |
| **Total** | **2,182.9** | **100.0** | **3,431.7** | **100.0** | **5,404.9** | **100.0** | **7,314.0** | **100.0** |

The relationship of the population 65 and over to males 20-64 years is of special interest. From 1901-1921 these two groups were in the ratio of one to five. By 1941 the ratio was one to four. At the last census (1956) the ratio was one to 3.3. In other words from 1901 to 1921 for every 100 males age 20-64 years there were 20 persons age 65 and over; in 1956 there were 30. Estimates to 1970 indicate that this figure will increase slightly to about 31 with 593,000 persons 65 and over and 1,890,000 males age 20-64 years.

### *THE HEALTH OF OLD PEOPLE*

At the beginning of the century, the first and second ranks among our causes of death were held by tuberculosis and pneumonia. These two causes accounted for over one-fifth of the total mortality. Since then, they have fallen to fifteenth and seventh place and now contribute barely one-twentieth of all deaths. Today, cardiovascular-renal disease and cancer account for almost three-quarters of the deaths at all ages.

The changing picture in mortality may be summed up in the relative proportions of deaths under 50 years of age and 50 years and over. In 1900-02, 56.8% of all deaths were at ages under 50 years. Thirty years later, in 1930-32, the position was reversed, 62.2% of all deaths occurring at age 50 years and over. Twenty-five years later still, in 1955-57, the picture is further accentuated; today about 80% (79.3%) of all deaths in Ontario (compared with 43.2% in 1901) occur among persons 50 years of age or over.

In 1953-1957 diseases of the cardiovascular-renal system (67.1%), cancer (14.6%), accidents (3.0) diabetes,

**TABLE VIII—ONTARIO'S OLDER CITIZENS—VARIOUS MEASURES, ONTARIO, 1901 TO 1975**

| Year | Population 65 and Over | | Population 20-64 | | Males 20-64 | | Pop. 65* to Pop. | Pop. 65* to Males | Males 20-64 |
|---|---|---|---|---|---|---|---|---|---|
| | No. | % | No. | % | No. | % | % | % | to Pop. 65* |
| 1901 | 120.6 | 5.5 | 1,147.4 | 52.6 | 571.1 | 26.2 | 10.5 | 21.1 | 4.74 |
| 1911 | 142.8 | 5.6 | 1,402.4 | 55.5 | 729.6 | 28.9 | 10.2 | 19.6 | 5.11 |
| 1921 | 172.3 | 5.9 | 1,621.0 | 55.2 | 819.5 | 27.9 | 10.6 | 21.0 | 4.76 |
| 1931 | 234.2 | 6.8 | 1,919.5 | 55.9 | 984.0 | 28.7 | 12.2 | 23.8 | 4.20 |
| 1941 | 301.2 | 8.0 | 2,223.0 | 58.7 | 1,135.2 | 30.0 | 13.5 | 26.5 | 3.77 |
| 1951 | 400.4 | 8.7 | 2,642.2 | 57.5 | 1,330.0 | 28.9 | 15.2 | 30.1 | 3.32 |
| 1956 | 454.4 | 8.4 | 2,985.3 | 55.2 | 1,506.8 | 27.9 | 15.2 | 30.2 | 3.32 |
| 1960* | 486.0 | 8.3 | 3,115.0 | 53.1 | 1,574.0 | 26.8 | 15.6 | 30.9 | 3.24 |
| 1965* | 538.0 | 8.2 | 3,386.0 | 51.6 | 1,710.0 | 26.1 | 15.9 | 31.5 | 3.18 |
| 1970* | 593.0 | 8.1 | 3,739.0 | 51.1 | 1,890.0 | 25.8 | 15.8 | 31.4 | 3.19 |
| 1975* | 661.0 | 8.1 | 4,192.0 | 51.2 | 2,118.0 | 25.9 | 15.8 | 31.2 | 3.20 |

**Estimated populations, Gordon Report, 1956.*

pneumonia and tuberculosis caused 91% of the deaths of persons at 65 years of age and over. Two-fifths of all deaths were attributed to diseases of the heart and coronary arteries.

The diseases which account for the majority of deaths in the older age groups are chronic or degenerative rather than acute or infectious. Their incidence is long term and relatively unvarying. Concerted efforts to reduce them have been started only fairly recently. While the expectation of life at age 50, 65 and above, especially in males, remains approximately the same as 20 or even 50 years ago, the health of old people as a group has already improved and it is inevitable that in the future we shall reduce the causes of invalidism at older ages, even simply as an indirect effect of accomplishments at ages under 65.

### *Public Health and Medical Issues*

The changes in population structure and in particular the great increase in the number of individuals age 65 years and over has brought with it increased health requirements which we must plan and be prepared to meet. This need is not coming; it is here now.

The seriousness of the health issues involved in our present mortality picture and our lengthening life span are emphasized, not only by the greatly increasing numbers of persons at older ages, but by a number of established facts in sickness, hospitalization and health service experience. These are worthy of brief reference:

### *INCIDENCE AND PREVALENCE OF ILLNESS*

Data from the Canadian Sickness Survey (1950-51) have provided ample evidence of the impact of the older age groups on the morbidity and health service load. Prevalence of illness and measures of disability increase sharply with age from adult life, those for persons 65 years of age and over being 50 to 100% above the figures at ages 45-64 years (Table IX).

**TABLE IX — PREVALENCE OF ILLNESS (Beginning of Survey)***

| Age | Illnesses per 1,000 | | Per Cent of Persons | |
|---|---|---|---|---|
| | Any Illness | Disabling Illness | Any Illness | Disabling Illness |
| Under 15 | 50 | 20 | 4.6 | 1.8 |
| 15-24 | 50 | | 4.7 | |
| 25-44 | 102 | 28 | 8.9 | 2.5 |
| 45-64 | 147 | 51 | 12.1 | 4.5 |
| 65+ | 256 | 100 | 18.6 | 7.0 |
| **All Ages** | **98** | **34** | **8.3** | **2.9** |

*Canadian Sickness Survey, 1950-51.*

The percentage of persons disabled by sickness or injury at a given point of time, at ages 45-64 is twice, and at ages 65 and over is three times what it is at ages 15-44 years. At ages 65 and over, 7.0% or one person in 14 has a disabling illness.

### *DISABILITY RATES*

The duration of disability or length of stay in bed or in hospital, whether expressed per person or per period, both increase three-fold at the older ages (Table X). The number of days of disabling sickness per person at all ages is 11.9 days; at ages 65 and over it is almost 27 days. For bed periods the figures are 5.6 days for all ages and 12.2 days for the older age groups (Table X).

**TABLE X — DISABILITY AND BED PERIODS***

| Age | Disability Periods | | Bed Periods | |
|---|---|---|---|---|
| | Aver. Days Per Person | Aver. Days Per Period | Aver. Days Per Person | Aver. Days Per Period |
| Under 15 | 10.4 | 6.8 | 5.3 | 4.9 |
| 15-24 | 8.4 | 9.2 | 3.8 | 5.9 |
| 25-44 | 9.3 | 9.9 | 4.8 | 6.7 |
| 45-64 | 15.3 | 17.5 | 6.2 | 9.8 |
| 65+ | 26.8 | 28.9 | 12.2 | 16.1 |
| **All Ages** | **11.9** | **10.8** | **5.6** | **6.9** |

*Canadian Sickness Survey, 1950-51.*

### *CHRONIC DISEASE*

There is a steep rise in the prevalence of chronic disease with age. At ages 70 and over the figure is five to six times

**TABLE XI — LIMITATION OF ACTIVITY VS AGE**

| Age | Per Cent With | |
|---|---|---|
| | Partial Limitation | Major Limitation |
| Under 15 | 1.2 | 0.2 |
| 15-29 | 4.0 | 0.5 |
| 30-44 | 7.2 | 0.8 |
| 45-54 | 11.3 | 1.7 |
| 55-64 | 17.6 | 4.4 |
| 65-74 | 27.8 | 9.4 |
| 75+ | 31.1 | 23.7 |
| **All Ages** | **8.0** | **2.1** |

*Source: U.S. National Health Survey Reports, 1958.*

what it is at younger ages. The recently established U.S. National Health Survey program has yielded a good deal of information on the relationship to age of morbidity and the need for health services. Apart from those persons hospitalized there is the larger group of people with some measure of chronic limitation of usual activity. These may be divided into those with "partial" and those with "major" limitation of activity (Table XI).

A measure of the reduced efficiency of the population is provided by expressing disability in terms of the time which usual activities are restricted (bed-disability days, work-loss days, and school-loss days). Here too there is a steep gradient with age (Table XII).

**TABLE XII — REDUCED EFFICIENCY BY AGE**

| Age | % Total Person Years | | Days per Person per Year | |
|---|---|---|---|---|
| | Restricted Activity Per Cent | Bed Disability Per Cent | Restricted Activity | Bed Disability |
| Under 5 | 3.6 | 1.6 | 13.2 | 5.8 |
| 5-14 | 4.5 | 2.1 | 16.4 | 7.7 |
| 15-24 | 3.7 | 1.7 | 13.5 | 6.2 |
| 25-44 | 4.3 | 1.6 | 15.7 | 5.8 |
| 45-64 | 7.0 | 2.4 | 25.6 | 8.8 |
| 65+ | 13.0 | 4.5 | 47.3 | 16.3 |
| **All Ages** | **5.5** | **2.1** | **20.0** | **7.8** |

*Source: U.S. National Health Survey Reports, 1958.*

### *PERMANENT DISABILITY*

The number of persons permanently disabled by chronic disease varies sharply with age also. In the population as a whole the total disability rate is about 8 per 1,000; for severe and total disability the rate is 30 per 1,000. At ages 65 and over, severe and total disability cases are estimated at 150 per 1,000 (Table XIII).

**TABLE XIII — PERMANENT PHYSICAL DISABILITY — CANADA, 1950-51**

| Age | All Severity Groups | | | Severe and Total Disability** | | |
|---|---|---|---|---|---|---|
| | Number | Per Cent | Rate* | Number | Per Cent | Rate* |
| Under 25 | 139,000 | 15 | 22 | 37,000 | 9 | 6 |
| 25-44 | 238,000 | 25 | 59 | 88,000 | 21 | 20 |
| 45-64 | 317,000 | 33 | 128 | 136,000 | 32 | 55 |
| 65+ | 263,000 | 27 | 242 | 162,000 | 38 | 150 |
| **Total** | **957,000** | **100** | **68** | **423,000** | **100** | **30** |

**Rate per 1,000 population.*
***99,000 were estimated to be totally disabled.*

### *MEDICAL CONSULTATIONS*

An individual consults his physician 300 times in his lifetime, five times per year at all ages for each sex. The demand for physicians' services also shows a strong age variation. At ages 65 and over the consultation rate is twice what it is at ages 15-44 years.

#### *General Practitioner Case Load*

Data on the clinical experience in general practice in England and Wales throw some light on the general practitioners' case and service load by age (S.O.M.A.P.S. No. 14, 1958); data for physicians' visits from the U.S. National Health Survey (1957) present a similar picture (Table XIV).

Except in childhood, females in general have higher rates than males, in respect of visits to general practitioners. Elderly patients (65 and over) have about twice as many consultations as children and young adults.

**TABLE XIV — CONSULTATION RATES**

| Age | England and Wales* | | United States** | |
|---|---|---|---|---|
| | Males | Females | Males | Females |
| Under 5 | 320 | 309 | 5.0 | 4.6 |
| 5-14 | | | 3.6 | 3.2 |
| 15-24 | 247 | 370 | 3.4 | 6.3 |
| 25-44 | | | 3.5 | 6.2 |
| 45-64 | 395 | 412 | 3.8 | 5.8 |
| 65+ | 586 | 641 | 5.8 | 7.6 |
| **All Ages** | **339** | **408** | **3.9** | **5.5** |

** Per 100 population.* *** Per Person.*

### *HOSPITAL UTILIZATION*

There is a substantial increase in the average length of stay in hospital per case with increasing age, from age 50 on. For every day of hospital care required per 1,000 population at ages under 65 years, two days are required at ages 65 and over (Table XV).

The steep increase with age in medical calls, disabling illness, chronic disease, invalidity, and hospital bed requirements, clearly indicate that since the health problems of older ages are now relatively much more important, the medical, nursing and hospital demands to be met in the future will be, to say the least, sizable.

Every practising physician has felt the impact of the changes in age structure of the population in recent years.

**TABLE XV — HOSPITAL UTILIZATION BY AGE**

| Age | Discharges per 1,000 Persons | Hospital Days per 1,000 Persons | Average Length of Stay (Days) |
|---|---|---|---|
| Under 15 | 53 | 294 | 5.5 |
| 15-24 | 72 | 615 | 8.6 |
| 25-44 | 83 | 706 | 8.5 |
| 45-64 | 98 | 1,187 | 12.0 |
| 65-74 | 119 | 1,700 | 14.3 |
| 75+ | 124 | 1,933 | 15.6 |
| **All Ages** | **79** | **757** | **9.6** |

*Source: U.S. National Health Survey Reports.*

The weight of this impact is going to increase rather than diminish. The pattern of disease incidence and mortality has shifted to feature the conditions of the older ages and those of a more chronic character. Home and visiting nursing experience reflects this complete reversal of need.

While there are more cases of cancer, heart disease, et cetera, in the population today, a person aged 65 is no more likely to develop heart disease, hypertension, arthritis, diabetes, or cancer, than he was 30 or even 50 years ago. The situation is simply that the person is more likely, if he develops the disease, to survive to the age of 65.

### *HOSPITALIZATION*

Trends in hospitalization have been steadily upward over the years. Approximately twenty per cent of the case load of general hospitals involves persons 65 years of age and over among whom cancer, diabetes, peripheral vascular disease, cerebral vascular accident, fractures of the hip or femur, prostatism, and senility predominate.

The facilities for caring for illnesses in the home have a decided influence on the request for hospital admission. Congestion in urban areas with multiple families in one dwelling often makes it extremely difficult to care for even the most minor illnesses. Such difficulties are accentuated by the lack of available help within the home.

### *MENTAL HOSPITALS*

The vast problem of mental disease is perhaps the most serious in the entire health field. The number of patients on the books of Ontario Mental Hospitals has increased from 10,390 in 1931 to 24,510 at the end of 1958, or 426 per 100,000 population.

The first admission rate for mental disease is low at ages under 15 years and changes very little from age 20 to age 65; in the age groups beyond 65 years, the admission rate is twice what it is in the younger age groups or at middle life.

The figures for the Province of Ontario show that although only 8.4% of the population is 65 years of age and over, 21% of the beds in the Ontario Mental Hospitals are occupied by persons at these ages; an additional 34% are in the age group 45-64 years. Of all first admissions, 22% are 65 years of age and over and of these, 85% are patients with senile psychoses or psychotics with cerebral arteriosclerosis. There are many more of these patients not in hospitals but for whom some additional provision is required.

### *CRIPPLED CHILDREN*

During 1958, a total of 1,246 infants were reported by physicians as born alive with an obvious congenital abnormality, 8.1 per 1,000 live births. Of these, 205 or 16.4% were premature. There were 1,506 abnormalities reported, 1,010 or 67.1% of which were congenital malformations; in addition there were 96 neoplasms, 220 cases of club foot and 57 cases of mongolism reported. Of 1,093 infants born alive in 1957 with a congenital abnormality, 359 or 32.8% died during their first year of life.

#### *The Problem*

The fact that the life span has been increased does not necessarily mean that the years that are added to our life span are healthy ones. Increased life expectancy increases the volume of morbidity. With children the more we reduce the hazards of life around the event of birth, the more we are faced with the survival of children with handicaps, with the problems of handicapped children who advance into later life. The same thing is true in the prolongation of life of persons with disease or other handicaps.

It is our pressing health problem to provide adequate health services, resources and facilities for the large and increasing numbers of the aged sick and for the children and adults suffering from disabling chronic conditions.

Although chronic diseases find the majority of their victims at older ages, the term "chronic sick" includes all age groups; infants and children with congenital heart disease, rheumatic heart disease, orthopaedic conditions; adults with tuberculosis, progressive nervous diseases; older men and women with arthritis, cancer, arteriosclerotic and cerebral vascular changes, and senile conditions of all types.

It has been said that the chronic aged sick have been inadequately cared for in the past and often receive scant attention. Certainly our few hospitals for chronic diseases are filled to overflowing and many patients in need of institutional care must wait until beds are available. In addition, there is a pressing necessity for a larger number of beds for the care of aged invalids and semi-invalids.

One of the most important single limiting factors today in relation to the care of the older citizens is the shortage of nursing staff. The potential source of nurses is the female population 17-20 years of age. The number of

young women in this age group declined in absolute numbers from 1939-41 and did not begin to turn upward until ten years later, in 1953, nor get above the pre-war level until 1956. The ratio of females 17-20 years to total population declined steadily from 1939 and this proportion will probably not regain its pre-war level until 1963-65. These facts pinpoint the nurse-power problem today.

### DISCUSSION

The lengthening life span is the net result of many forces but the major gain has been made largely through reduction in infant mortality and the prolongation of life of persons with chronic disease. This has tended to increase, relatively and absolutely, the problem of congenital and other crippling conditions in children and the sub-standard or handicapped individuals at all ages in the population.

The chronic diseases, the diseases and conditions which attack middle aged and elderly people, are our major health problems today.

Chronic disease and disability is a function of age, but also, with the great reduction in infant mortality, the number of congenitally malformed and handicapped children become a more significant problem.

Physiological age is not synonymous with chronological age. A man's usefulness does not necessarily begin to diminish at age 45, nor terminate at age 65. Recognition of this fact is of great significance not only to the employers but to all health professions and to all community health and social workers.

The public health aspects of the problems of an aging population are of increasing importance; they call for planned action and conscious interest of all public health authorities.

The changes which have taken place in the demographic picture require suitable adjustments in the public health programs. More and more activities must be concentrated on the diseases and conditions which affect the older age groups. Public health administration must adapt its services and facilities to meet the health needs of the middle aged and older people, and the chronic disease problems generally.

It is imperative that we give due consideration to all practical measures which can be applied to the maintenance of the health of the aging, and to the postponement of the day when they will require a great deal of assistance, and eventually full bed-care. Where there has been deterioration in health, or sickness or injury, the problem becomes one of rehabilitation.

Increase in the average life span, because of its origin, brings greater emphasis on problems long out of focus — congenital abnormalities, chronic disease, geriatrics. The future calls for: (a) a drive on those diseases which are specifically associated with older age; (b) increasing emphasis on medical research on congenital abnormalities, on the degenerative diseases and on the problems of old age; (c) provision of much needed hospital, home, and rehabilitation facilities for the chronic sick, the handicapped and the aged; (d) attempts to meet the demands for more comprehensive health care which are inescapable.

There are gaps in our health services, using "health services" in its most comprehensive sense; these must be and are being closed. Social medicine is developing solutions for the various defects in our system as it exists and as these changes occur, the health professions will have to adjust to fit it. This process will involve a greater integration of all health, hospital and welfare authorities in the public interest. Indeed, the close co-operation and collaboration of all health, hospital and welfare authorities is required to meet the present and the future need!

The objective of the combined efforts of all those concerned with the health and welfare of our people, governmental and voluntary, public and private, must be to "add life to years and not just years to life", so that it will not again be possible for anyone to say "You don't really live longer, it only seems longer".

### SUMMARY

The intensity and character of the need and the demand for health services is influenced to a large degree by demographic and social changes in our population. In common with other provinces of Canada and other countries, particularly in the Western World, the twentieth century has brought sharp changes in Ontario's population structure, in the expectation of life, and in the character of the major health problems in terms of needs for services and facilities.

Mortality from the infective diseases has declined dramatically; from 20% of all deaths in 1900 to only 1% today. Infant mortality rates have declined by 80% during the past 50 years from over 120 per 1,000 live births to 25 in 1957. Neonatal mortality has also declined substantially, but at a slower rate. At the beginning of this century, 57% of all deaths occurred at ages under 50 years; today almost 80% of all deaths occur among persons over 50 years of age. During the last 25 years, substantial reductions in mortality have occurred in all age groups, up to age 45. For males at ages 55-64 and 65 and over, however, very little improvement has been effected. Sex differences in mortality are a signal disturbing feature of our present mortality picture. Male mortality exceeds female mortality throughout the life span and the gap has widened sharply in the last 25 years. Life expectancy at birth has increased rapidly over the years to 67.8 years for males and 73.6 for females in 1956. There has been little improvement in life expectancy for the Canadian male at ages 50 and over during the last 25 years, perhaps 3 or 4 months at age 50 and at age 65 compared with 3 and 2 years respectively for females. Men have shared much less than women in this gain in life expectancy, especially at ages 50 and over.

Ontario's population is growing at the rate of about 200,000 or 3% per year. Persons 65 years of age and over comprise 8.4% of the total population and the number is increasing by 10,000 per year. The older segments of our population are growing in importance and require larger measures of health care. These available facts together make certain points clear: (a) there are more people alive today, both absolutely and relatively, at ages when the incidence of chronic disease is highest; (b) there will therefore be a greater absolute number of persons who develop or who are alive with chronic disease; and (c) the morbidity and mortality from chronic disease form a greater proportion of total morbidity and mortality now than formerly.

Chronic disease will command increasing interest in the future and the relative and the absolute volume of service to be provided by all health personnel and facilities may be expected to increase substantially. Increase in the average life span, because of its origin, brings greater emphasis on problems long out of focus — chronic disease, geriatrics. Gaps in our present system must be met, a process which will involve a greater integration of health and welfare activities in the public interest. The fact that the life span has been increased does not necessarily mean that the years that are added to our life span are healthy ones. The more we reduce the hazards of life around the event of birth, the more we are faced with the survival of children with handicaps, with the problems of handicapped children who advance into later life; the same thing is true in the prolongation of life of persons with diseases or other handicaps. Social medicine is developing solutions for the various defects or gaps in our system as it exists and, as these changes occur, the health professions will have to adjust to fit in. The problem before health personnel, governmental or voluntary, private or public, is to add life to years and not just years to life! The close co-operation and collaboration of health, hospital and welfare authorities is required to meet the present and future needs.

***ACKNOWLEDGEMENT***

I should like to acknowledge the valuable assistance of my staff in the preparation of the data used in this paper; without the keen interest of these workers, this presentation would not have been possible.

# *New Publication*

## INDUSTRIAL VENTILATION

Reviewed by

***C. R. ROSS, M.S., P. Eng.***

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A manual of recommended practice, 6th Edition, 1960. American Conference of Governmental Industrial Hygienists, Committee on Industrial Ventilation, P.O. Box 453, Lansing 2, Michigan, U.S.A., $4.00.

This manual is the work of an association actively concerned with the control of occupational health hazards by means of properly designed ventilation systems. The first edition appeared in 1951 and the 5 editions and 9 printings which have appeared since then are evidence of its acceptance as an authoritative reference.

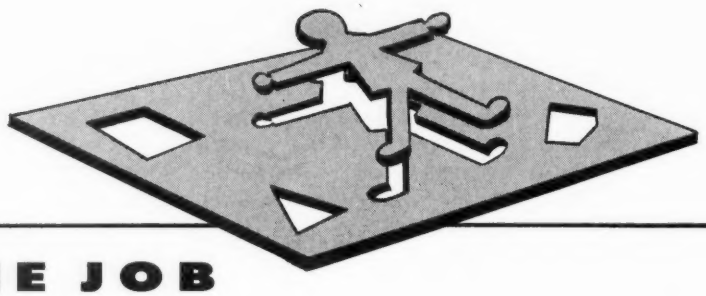
Featured in the volume are data sheets, illustrating eighty model hoods applicable to specific industrial operations. Most of these are based on designs in current use in successful industrial ventilation systems and while intended only as guides, can usually be copied with only slight modification. In this edition, minor changes have been made to a number of the hood data sheets (C-S addition of references to methods of design); spray paint booth ventilation rates have been increased in some cases and there is a new data sheet on canopy hoods. In redrawing one illustration (VS — 10A) an error was made in the accompanying note (2000 fmp should read 200 fpm).

Other sections of the manual deal with hood and duct design procedures applications of makeup and recirculated air systems, air-flow measurement fans and air cleaning devices. The makeup air section has been completely rewritten and extensive changes made to the section on testing ventilation systems. All parts of the manual are clearly written and design procedures are simply presented.

The manual is recommended as a most useful reference to anyone concerned with design, installation or maintenance of industrial ventilation systems.

*Reprinted from a paper presented at the second Occupational Health Conference, held in Vancouver, March, 1959.*

# *Fitting the Worker*



# TO THE JOB

**BY E. P. FRIESEN, Ph. D.**

*Stevenson & Kellogg Ltd.*

## I. A COMPLEX MATTER

How well a worker will do in any position is probably dependent upon the interplay of quite a few factors. In the first place, the man must be suited to the actual duties of a job by mental, personality, and physical aptitudes. In this is included the required interests and appropriate motivations. In addition, his physical condition or health is important. Also, the personality and competence of the supervisor greatly affects the performance of the man, as do the behaviour and the policies of management personnel. The physical facilities of the work place or work situation also affect performance. Finally, the man's general life adjustment, in which is included his home life at present, is a pertinent factor. Consequently, if one considers the proper selection and placement of a worker, one is in fact considering only one significant aspect of his productivity and adjustment to the job — albeit a very important factor.

## II. WHAT ARE THE CONTRIBUTIONS OF AN INDUSTRIAL PSYCHOLOGIST TO FITTING THE WORKER TO THE JOB?

A) By devising specialized psychological tests of emotional, mental, and physical traits and capacities, as well as specialized interviewing techniques, the Industrial Psychologist has been able to make a significant contribution to the "matching" of the man to the job.

B) By devising measures of employee feelings and attitudes the Industrial Psychologist can give supervisors and management personnel some significant clues as to why people react and intereact as they do, and how this affects productivity and adjustment.

C) By applying the known laws of human learning to the problems of industrial training, the time required for skill development can be shortened.

D) By participating in and training others in regard to personnel counselling and career planning, a good deal can be done to ensure the orderly and profitable utilization of human talents to a point approaching the maximum possible, with greater satisfaction to all concerned.

E) By scientific study of the underlying human elements or factors which motivate the behaviour of employee groups and which strongly influence employer-employee relationships, valuable clues as to the development of a team spririt and the releasing of human motivations can be acquired.

F) By studying existing job content and re-designing this in order to suit human capacities and motivations a good deal can be done towards increasing productivity, efficiency, and morale.

G) A variety of other approaches have been developed in relation to performance or merit rating, work measurement in order to establish the actual productivity of a worker, accident causation and prevention, and efficient work place arrangement. All of these relate to matters normally dealt with by management, but the Industrial Psychologist's particular contribution is the uncovering of the human factors which underlie the effective application of such methods or systems.

## III. A BIRD'S-EYE VIEW OF SOME ACCOMPLISHMENTS IN SELECTION AND PLACEMENT

### A — Selection of Machine Bookkeepers

Twenty-two machine bookkeepers were selected on the basis of their scores on an "Office Operations" test. The level of their performance was predicted by this test and

later matched with their actual performance level. Of the twelve persons who were later on rated as being in the "top half" of the group, ten had been so designated initially by their test performance. Of the ten persons who actually turned out to be in the bottom half of the group by actual performance, nine had been so identified by their test scores. All together there were nineteen "hits" and three "misses". Prediction accuracy was 86%.

### *B — Overall Plant Productivity*

A Personnel Director, working with one of British Columbia's largest primary producers, reports the following results accruing from the use of carefully selected tests and interviewing procedures. Prior to "start-up" his plant was rated at 300 units daily capacity. The majority of plant employees and all of the supervisors and managerial personnel were carefully screened and placed by appropriate test and interview procedures. After five months of operation the actual daily productivity was 400 units — a 100 units over the estimated initial capacity — which was achieved many months before it had been anticipated. It is reported that this was more or less of a record in the industry. At the same time, another plant in another province with apparently similar rated capacity in producing a similar product was put into operation — without the benefit of specially prepared testing and interviewing programs. After a year of operation it is reported that this plant still has not achieved its rated capacity. Obviously, there are many factors responsible for the records set by the first plant mentioned, in which would be included management and its policies. However, care in the selection of personnel is reported by management to be very definitely a significant factor in the production record achieved. Typical comments of the staff as reported to us might also be interesting: "This is an unusual plant in which to work — people get along with one another, work is orderly, and you know what is expected of you — and you feel you can do it."

### *C — Pointing Up The Causes of Poor Morale*

The average score for the direct labour group in a factory on a test of mental alertness is 15. The average score for the supervisory group was 15, and the average score for the executive group 25. A few months after this test had been administered, the Plant Superintendent was asked to identify who the "trouble makers" in his plant were. He named thirteen. Of these thirteen, ten were above the factory direct labour group average (ranging from 16 — 23), and nine were above the average for foremen (ranging from 17 — 23). From this one might conclude that the majority of the "trouble makers" were too bright for their jobs — and probably even brighter than their supervisors. This could conceivably make them less happy with their work and/or cause their supervisors to feel that they were troublesome.

### *D — Personality Tests and Problem Employees*

By means of a short personality questionnaire Employment Interviewers can be helped to identify potential personality problems among applicants. Here is the profile of an employee who was reported to be repeatedly cruel and unsympathetic, and threw hot dope at a fellow employee he didn't like;

| TRAITS | RATING |
|---|---|
| Objectivity — sense of realism | very low |
| Feelings of persecution | high |
| Self-assertiveness | above average |
| Emotional control | low |
| Bizarreness in responses | high |

### *E — Predicting Ability to Learn Work of a Mechanical Nature*

Fourteen candidates were selected on the basis of scores on a block counting test for mechanical work. Of the ten men who were rated by this test as above average ability to learn work of a mechanical nature, eight were later rated by their superiors as fast learners. Of the four who were rated by test results as below average, two were later on rated by their superiors as slow learners. Prediction accuracy was ten out of fourteen or 71%.

### *F — Avoiding Wastage of Human Resources by Better Placement*

With proper time and study, many cases of this type could be cited. However, at the moment I recall the case of a civil engineer whose test results indicated sales interests and a sales personality. He was employed with a major oil company as a Field Surveyor. He was ready to quit his job at the time of testing and interviewing. The Personnel Manager was informed of his potential talents. The Company took the advice and put him in the marketing department where management later on reported that he was doing well. A personal discussion with him about a year after his re-placement indicated that he too felt he was doing better and was happier in his new form of work.

### *G—Financial Profitability of Comprehensive Application of Industrial Psychology to Fitting the Worker to the Job*

Here is the typical experience of a company using psychological selection, training, and incentive procedures. On the subject of *earnings* — at the beginning of the first year, prior to installation of these procedures, the percentage of earnings to base pay was 125. At the year's end it was still 125. However, at the beginning of the second year the percentage of earnings to base pay was 138 and at the end of the second year it was 160. In relation to *performance or productivity* — at the beginning

of the first year, the percentage of performance to the standard set was 95; at the year's end it was 110. At the beginning of the second year it was 115 and at the end of the second year the percentage of performance to standards was 158. It was during the first year that the new procedures were installed. The selection procedures were installed in June, the training program in July, the job standards were completed in November, and the incentive system completed in December of the first year. You will note that the employees earnings over base increased 35% from December to December and the productivity over standard increased 63%. This would illustrate, it would seem, increased financial returns for both management and the worker. In connection with this same company, some other statistics might be interesting. For example, in regard to the *percentage of applicants hired* — at the beginning of the first year (before installation of the revised personnel procedures), 95% of the applicants were hired. At the year's end 15% were. At the beginning of the second year 15% of the applicants were hired and at the end of the second year about 20%. You will note the drastic reduction in the percentage of persons hired due to much greater care in selection being taken — namely, 95% to 20%. In regard to *monthly labour turn over* — at the beginning of the first year it was 15%. At the end of the second year it was 6% — making a decrease of 9% in turn over. Finally, in regard to the *percentage of scrappage* in production departments, at the beginning of the first year it was 98%, at the end of the second year it was 7% — you will note a decrease of 91%.

### *H — Costs of Industrial Psychological Services Versus Labour Cost Reductions Possible*

I will speak from the point of view of the Consultant Psychologist. I must speak in general terms since detailed data could not be prepared in time.

It is generally calculated that the annual total cost for an ordinary clerk is $4,800 — including salary, training costs, selection costs, fringe benefits, and so forth. Let us assume that under normal circumstances without careful selection 50% of a clerical staff is only 50% productive. Assume that the number of clerks is ten. The annual excess cost (represented by five clerks with only 50% productivity) is five times $2,400 or $12,000. Let us now assume that the same size of clerical staff is selected by psychological evaluation. It is logical to assume that the percentage of poor workers (50% productivity) is now only 20% — rather than 50%. Thus the excess annual cost would be two times $2,400 or $4,800. The cost of selecting ten clerical workers with only two out of ten being inadequate would be approximately $75.00 for each good employee selected — making a total of $750.00. Therefore, the annual excess cost is now $5,550. The reduction in labour costs, therefore, could be $6,460. or roughly 54%.

Similar results for other occupational categories are possible. When one multiplies such savings in cost by the number of occupational categories in a company, some idea of the relatively low comparative cost of proper selection should become apparent. Savings, when executive personnel or supervisory personnel are considered, can even be much greater, to say nothing of the greater contributions such better-selected key people can make.

The industrial plant referred to earlier provides another example of labour cost reduction. No definite figures are available, but when you consider what the increased productivity must have meant to the profit picture of this company (assuming that sales were maintained) some general idea of the benefits accruing from psychological evaluation of personnel may become apparent to you.

### *IV. IN CONCLUSION*

In general, if business and industry will learn to give the policy and financial support to the services which the Industrial Psychologist can render in selection and placement of workers alone, some remarkable changes in our productive capacity and human satisfaction for both management and employees could occur. The knowledge and skills which are now available to an enlightened employer could make it possible for him to select the practical level of productivity he wishes to have in his business or industry — assuming, of course, that there are a sufficient number of available employees from which to select the ones that are suited to his situation and to the particular kinds of work done in his organization.

OTTAWA
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# Ventilation Requirements

**BY L. RISPLER, B.Sc., P. Eng.**

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When lead-acid storage batteries are charged, gases are formed which escape freely during the latter part of the charge. Oxygen is evolved at the positive plates and hydrogen at the negative plates. Since four per cent of hydrogen in air is the lower limit of flammability, precautions should be taken to prevent explosions. Smoking, or the use of open flames, or of tools which may generate sparks should be avoided; and suitable ventilation should be provided to prevent the accumulation of an explosive mixture. Ventilation is also desirable for removing any acid spray and cooling the batteries.

The amount of hydrogen liberated from the negative plates depends on the condition of the battery and the amount of charging current applied. As the charging rate is decreased the amount of hydrogen evolved per ampere-hour is decreased; indicating that a battery is limited to a certain rate of chemical reactions and that when the current applied becomes greater than that required to give this limiting amount, the excess current is wasted in electrolysis. In other words, a fully discharged battery can absorb a greater amount of current during the initial stage of recharging without liberating gases than it can during the final stages when it approaches a fully charged condition, and unless the charging rate is reduced as the batteries approach full charge, the liberation of hydrogen will increase rapidly toward the end of the charging period. The maximum amount of hydrogen is given off when all the current applied is expended in electrolysis after the cell has become fully charged, and equals 0.01474 cubic foot of hydrogen at normal temperature and pressure per ampere-hour of charge.

To select a desirable ventilation rate for a battery-charging room the air quantity required to dilute the maximum amount of hydrogen that could be produced to a concentration of 1.5 per cent may be calculated. Considering a dilution efficiency of ⅓, the design ventilation rate for each cell would be 1/20 cfm per ampere expended in electrolysis.

$$\left(\frac{0.01474\ \text{ft.}^3}{\text{amp-hour}} \times \frac{\text{hour}}{60\ \text{min.}} \times \frac{100}{1.5} \times 3\ (\text{eff.}) = 0.05\right)$$

The maximum quantity of electricity that could possibly be expanded in gassing for any given battery-charging room is difficult to accurately predict because it would vary with the type of battery-charging circuit used, the capacity of the rectifiers, the number of cells and the condition of the batteries, etc. Therefore, unless this data is accurately known, it is suggested that the design ventilation rate be based on the assumption that the rated output of the rectifiers could be expended in electrolysis. For example, consider a battery-charging room with provision for charging seventy 24-volt batteries at a maximum charging rate of 5 amperes per cell. On the basis of this maximum charging rate being expended in electrolysis the design ventilation rate would be 210 cfm.

$$\left(\frac{0.05\ \text{cfm}}{\text{ampere}} \times 70 \times 12\ \text{cells} \times \frac{5\ \text{amperes}}{\text{cell}} = 210\ \text{cfm}\right)$$

Under circumstances where the only available information is the size of the room to be used for battery-charging, a general ventilation rate of 2 cfm per square foot of floor area of the room could be estimated.

When the ventilation system is installed the location of air inlets and outlets should be carefully chosen for uniform air distribution throughout the room. Some safety features could be incorporated into the design, such as an electrical interlock which would ensure that the fans are running whenever the charging equipment is used, and an alarm that would be energized whenever the design ventilation rate is not being obtained. Finally, after the system is in operation it should be periodically maintained and checked to assure efficient operation.

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# OCCUPATIONAL HEALTH REVIEW

"The program of the Occupational Health Division is concerned with service, research and education in the field of Occupational Health, and of Air Pollution in Canada.

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